Influence of Sedimentary and Seagrass Microbial Communities on Shallow Water Benthic Optical Properties

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LONG-TERM GOALS

An overall goal of the CoBOP program is to produce a working radiative-transfer model for selected sub-littoral environments. From a microbiological context, it is important to investigate the entire community of microorganisms associated with the benthic environments of focus, i.e., sediments and seagrass. Light must pass through a "microbial gateway", both before it reaches the sediment or seagrass and prior to its return to the water column. To understand time-and-space variations in optical parameters, we must understand the microbial milieu in which they exist.

OBJECTIVES

At both study sites, Lee Stocking Island in the Bahamas and Monterey Bay, California, I wish to quantify and identify the major functional groups of microorganisms in sediments and on seagrass blades. Given a characterization of microbial biomass and composition, the data can be combined with the first-principles information collected by other CoBOP sediment researchers (including other microbiologists, sedimentologists, organic geochemists, seagrass ecologists) and delivered to the optical modelers for input to their radiative-transfer models.

APPROACH

My approach is to combine extensive field sampling of sediments and seagrasses with biochemical determination (membrane lipids) and microscopic examination (light and scanning electron microscopy) of their microbiological constituents.

WORK COMPLETED

The field program has been an active one. Since fall of 1997, my group and I have collected samples from Monterey Bay five times and from Lee Stocking Island (LSI) three times. Both sediment and seagrasses have been collected to determine microbial biomass and microbial community composition using lipidological methods.

In addition, my group and I have collected seagrass samples to study their epiphytes using light and scanning electron microscopy. This information has been used in the creation of a photon budget for seagrasses (in collaboration with Dr. Richard Zimmerman).

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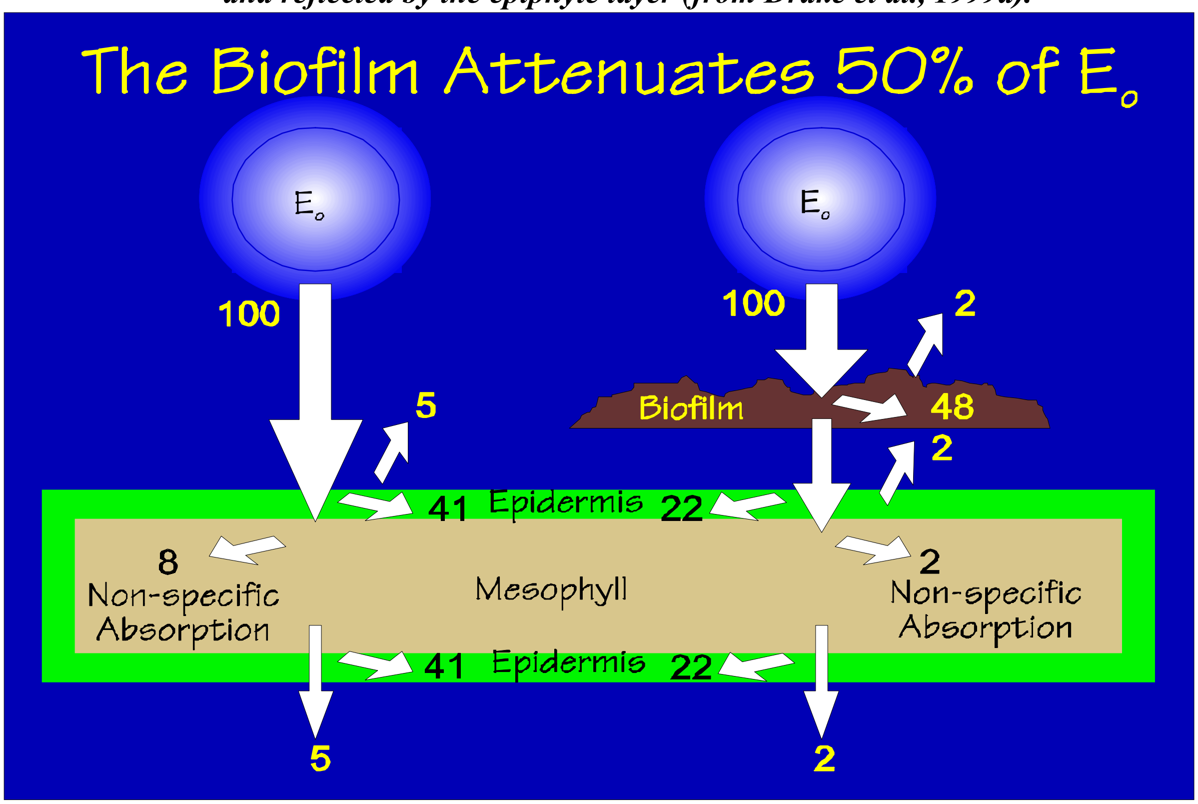
Finally, I have begun to test my coupling of an Ocean Optics S-2000 spectrometer with a compound microscope and have acquired fluorescent spectra of individual algal cells.

RESULTS

Microorganisms potentially have important ramifications for the optical properties of sediments. Among the various types of sediment distributed around LSI, I have determined a 20-fold difference in microbial biomass between the end members. In Monterey Bay, microbial biomass exhibits less spatial heterogeneity and relatively little temporal dynamic. In comparison with LSI samples, those from Monterey Bay demonstrate intermediate values of microbial biomass.

I used lipid biomass techniques to demonstrate an exponential increase in epiphyte biomass on LSI turtle grass as the leaves age. These lipid data confirm and quantify our observations made using both light microscopy and scanning electron microscopy. These observations were coupled with spectrophotometric measurements (made by Dr. Richard Zimmerman) of the absorbance and reflectance of incident light on intact leaves and leaves with the epiphyte layer removed. A subsequently calculated "photon budget" yields the conclusion that fully half of the incoming photons at 440 nm are absorbed and reflected by the epiphyte layer (Fig. 1; Drake et al., 1999a,b).

1. Photon budget of Thalassia testudinum Leaf 4. In vivo IOPs, measured by Zimmerman's group using an integrating sphere scanning spectrophotometer on fouled and cleaned leaves, were used to calculate the effect of the biofilm. One-half (50%) of the incoming photons at 440 nm are absorbed and reflected by the epiphyte layer (from Drake et al., 1999a).



Coupling the S-2000 spectrophotometer to the compound microscope has proven exciting. Although data are preliminary and issues of calibration need to be addressed, I have shown in "proof of concept" that the hybrid instrument can obtain fluorescent spectra of individual cells (e.g., endosymbionts of *Montastrea cavernosa*) and the absorbance spectra of *Thalassia* leaves variously colonized by epibionts.

As required by Program Manager Steve Ackleson, we have and will continue to submit our data in a timely fashion. The following data sets were submitted to the CoBOP database on 20 February 1999: Sediment Microbial Biomass (LSI May 1998, Monterey September 1997, Monterey April 1998, Monterey October 1998); Epiphyte Biomass (LSI May 1998; Monterey October 1998).

IMPACT/APPLICATIONS

Any surface in an aquatic environment is covered to some degree with a microbial menagerie that may affect the quantity and spectral quality of light for at least several different reasons. Thus, before incoming light reaches the sediment or seagrass blades and before any light returns to the water column, it must pass through a microbial "gateway" that may affect its quantity and quality. The present incorporation of microbiology into environmental optics research sets the stage for future investigations, in which not only closure is a goal, but a more precise understanding of the interactions between light and organisms.

TRANSITIONS

None at present.

RELATED PROJECTS

1) My post-doctoral associate, Lisa Drake, and I are collaborating with Richard Zimmerman (Moss Landing Marine Laboratory) to study the effects of seagrass epiphytes on leaf IOPs and the photon budget of eelgrass in Monterey Bay and turtlegrass at Lee Stocking Island.
2) Charlie Mazel (Physical Sciences, Inc., Andover, MA) and Ken Voss (Univ. Miami) have used their instruments (benthic spectrophotometer and bi-directional reflectance meter, respectively) to obtain in-situ data from LSI sediments I immediately sampled for microbial biomass analyses.
3) In a limited but spectacular demonstration in 1998, other members of the Sediment Group and I assisted Mike Strand (Naval Surface Warfare Center) and his group with a pilot project in which different sediment types were "planted" at the North Perry site (LSI) and visualized with FILLS.
4) In 1999, a subset of the CoBOP participants (Brand, Burdige, Decho, Dobbs, Mazel, Wheatcroft) performed an experiment at the North Perry site (LSI) to quantify the time scales on which recolonization of the sediment surface film occurs following disturbance.

REFERENCES

Drake, L.A. R.C. Zimmerman, M.E. Cummings, and F.C. Dobbs. 1999a. Epiphyte load on seagrass leaves: Effects of leaf age and influence on inherent optical properties. Aquatic Sciences Meeting, American Society of Limnology and Oceanography. Santa Fe, New Mexico.

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